

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063 2064 2065 2066 2067 2068 2069 2070 2071 2072 2073 2074 2075 2076 2077 2078 2079 2080 2081 2082 2083 2084 2085 2086 2087 2088 2089 2090 2091 2092 2093 2094 2095 2096 2097 2098 2099 2100 2101 2102 2103 2104 2105 2106 2107 2108 2109 2110 2111 2112 2113 2114 2115 2116 2117 2118 2119 2120 2121 2122 2123 2124 2125 2126 2127 2128 2129 2130 2131 2132 2133 2134 2135 2136 2137 2138 2139 2140 2141 2142 2143 2144 2145 2146 2147 2148 2149 2150 2151 2152 2153 2154 2155 2156 2157 2158 2159 2160 2161 2162 2163 2164 2165 2166 2167 2168 2169 2170 2171 2172 2173 2174 2175 2176 2177 2178 2179 2180 2181 2182 2183 2184 2185 2186 2187 2188 2189 2190 2191 2192 2193 2194 2195 2196 2197 2198 2199 2200 2201 2202 2203 2204 2205 2206 2207 2208 2209 2210 2211 2212 2213 2214 2215 2216 2217 2218 2219 2220 2221 2222 2223 2224 2225 2226 2227 2228 2229 2230 2231 2232 2233 2234 2235 2236 2237 2238 2239 2240 2241 2242 2243 2244 2245 2246 2247 2248 2249 2250 2251 2252 2253 2254 2255 2256 2257 2258 2259 2260 2261 2262 2263 2264 2265 2266 2267 2268 2269 2270 2271 2272 2273 2274 2275 2276 2277 2278 2279 2280 2281 2282 2283 2284 2285 2286 2287 2288 2289 2290 2291 2292 2293 2294 2295 2296 2297 2298 2299 2300 2301 2302 2303 2304 2305 2306 2307 2308 2309 2310 2311 2312 2313 2314 2315 2316 2317 2318 2319 2320 2321 2322 2323 2324 2325 2326 2327 2328 2329 2330 2331 2332 2333 2334 2335 2336 2337 2338 2339 2340 2341 2342 2343 2344 2345 2346 2347 2348 2349 2350 2351 2352 2353 2354 2355 2356 2357 2358 2359 2360 2361 2362 2363 2364 2365 2366 2367 2368 2369 2370 2371 2372 2373 2374 2375 2376 2377 2378 2379 2380 2381 2382 2383 2384 2385 2386 2387 2388 2389 2390 2391 2392 2393 2394 2395 2396 2397 2398 2399 2400 2401 2402 2403 2404 2405 2406 2407 2408 2409 2410 2411 2412 2413 2414 2415 2416 2417 2418 2419 2420 2421 2422 2423 2424 2425 2426 2427 2428 2429 2430 2431 2432 2433 2434 2435 2436 2437 2438 2439 2440 2441 2442 2443 2444 2445 2446 2447 2448 2449 2450 2451 2452 2453 2454 2455 2456 2457 2458 2459 2460 2461 2462 2463 2464 2465 2466 2467 2468 2469 2470 2471 2472 2473 2474 2475 2476 2477 2478 2479 2480 2481 2482 2483 2484 2485 2486 2487 2488 2489 2490 2491 2492 2493 2494 2495 2496 2497 2498 2499 2500 2501 2502 2503 2504 2505 2506 2507 2508 2509 2510 2511 2512 2513 2514 2515 2516 2517 2518 2519 2520 2521 2522 2523 2524 2525 2526 2527 2528 2529 2530 2531 2532 2533 2534 2535 2536 2537 2538 2539 2540 2541 2542 2543 2544 2545 2546 2547 2548 2549 2550 2551 2552 2553 2554 2555 2556 2557 2558 2559 2560 2561 2562 2563 2564 2565 2566 2567 2568 2569 2570 2571 2572 2573 2574 2575 2576 2577 2578 2579 2580 2581 2582 2583 2584 2585 2586 2587 2588 2589 2590 2591 2592 2593 2594 2595 2596 2597 2598 2599 2600 2601 2602 2603 2604 2605 2606 2607 2608 2609 2610 2611 2612 2613 2614 2615 2616 2617 2618 2619 2620 2621 2622 2623 2624 2625 2626 2627 2628 2629 2630 2631 2632 2633 2634 2635 2636 2637 2638 2639 2640 2641 2642 2643 2644 2645 2646 2647 2648 2649 2650 2651 2652 2653 2654 2655 2656 2657 2658 2659 2660 2661 2662 2663 2664 2665 2666 2667 2668 2669 2670 2671 2672 2673 2674 2675 2676 2677 2678 2679 2680 2681 2682 2683 2684 2685 2686 2687 2688 2689 2690 2691 2692 2693 2694 2695 2696 2697 2698 2699 2700 2701 2702 2703 2704 2705 2706 2707 2708 2709 2710 2711 2712 2713 2714 2715 2716 2717 2718 2719 2720 2721 2722 2723 2724 2725 2726 2727 2728 2729 2730 2731 2732 2733 2734 2735 2736 2737 2738 2739 2740 2741 2742 2743 2744 2745 2746 2747 2748 2749 2750 2751 2752 2753 2754 2755 2756 2757 2758 2759 2760 2761 2762 2763 2764 2765 2766 2767 2768 2769 2770 2771 2772 2773 2774 2775 2776 2777 2778 2779 2780 2781 2782 2783 2784 2785 2786 2787 2788 2789 2790 2791 2792 2793 2794 2795 2796 2797 2798 2799 2800 2801 2802 2803 2804 2805 2806 2807 2808 2809 2810 2811 2812 2813 2814 2815 2816 2817 2818

Brinks, Hofer, Gilson & Lione Case No. 10541/273  
Visteon Case No. V200-0914

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE  
APPLICATION FOR UNITED STATES LETTERS PATENT

INVENTORS: GREG A. WHITLOW  
WEN FEI YU

TITLE: HEAT EXCHANGER TUBE WITH  
STONE PROTECTION APPENDAGE

ATTORNEY: ZACHARY HAMILTON  
BRINKS HOFER GILSON & LIONE  
P.O. BOX 10395  
CHICAGO, ILLINOIS 60610  
(312) 321-4200

## HEAT EXCHANGER TUBE WITH STONE PROTECTION APPENDAGE

### BACKGROUND OF THE INVENTION

#### Field Of Invention

5           The present invention relates generally to a heat exchanger tube for use in a heat exchanger and, more particularly, to a heat exchanger tube with a stone protection appendage.

#### Discussion Of Related Art

10           Fig. 1 shows a cross-sectional view of a conventional heat exchanger flat tube of this kind. The heat exchanger tube 11 is made by extruding an aluminum article. The tube 11 has a peripheral wall 12 having an elongated circular cross-sectional shape and a plurality of divisional walls 13, 13a connecting flat wall portions 12a of the peripheral wall 12. The divisional walls 13 divide an inside space of the tube 11 to form a plurality of unit passages 14, 15 arranged in a lateral direction of the tube 11. Each divisional wall 13, 13a has a constant thickness along the height thereof so that a contact area with the heat exchanging medium can be enlarged, thereby enhancing the heat exchanging performance of the tube 11. The tube 11 includes outermost unit passages 14 and intermediate unit passages 15 located between the  
15           outermost unit passages 14. Each intermediate unit passage 15 has a rectangular cross-sectional shape, and each outermost unit passage 14 has a semi-circular cross-sectional shape at a lateral outside portion and a rectangular cross-sectional shape at lateral inside portion. Further, each portion of the tube 11, i.e., the peripheral wall 12 and the divisional walls 13, 13a, are formed to be as thin as possible for the purpose of lightening the  
20           weight of the tube 11.

25           Further, when the above-mentioned tube 11 is used in a condenser mounted in an automobile, tube 11 may sometimes become damaged and cause leakage of the heat exchanging medium when a stone, or the like, hits  
30           the tube 11 while the automobile is moving.

## BRIEF SUMMARY OF THE INVENTION

Two objects of the present invention are to provide both protection of the tube body against a stone or the like which hits the tube, and an excellent heat exchanging performance by keeping a large contact area with a heat exchange medium.

According to one aspect of the present invention, the above-referenced objects can be achieved for use in a vehicle by a heat exchanger tube extending in an axial direction that has an end. The end has a first and second appendage attached to it, such that, the first appendage and the second appendage are spaced from one another and the second appendage does not form an enclosed space with the first appendage.

According to another aspect of the present invention, the above-referenced objects can be achieved for use in an automotive air conditioner by a heat exchanger tube extending in an axial direction that has an end. The end has a first and second appendage attached to it, such that, the first appendage and the second appendage are spaced from one another and the second appendage does not form an enclosed space with the first appendage.

Each of the above aspects of the present invention protects the tube's body from being damaged by the use of the nose-tip-appendage. So that when an object, such as a stone, hits the tube, the nose-tip-appendage would collapse, absorbing the energy of the incoming object. Furthermore, although the present invention may be used in an automotive air conditioner, the present invention may also be used in a radiator oil cooler and, as stated above, the present invention may also be use in a residential heat exchanger.

Additional aspects and advantages of the present invention will become apparent from the following description and the appended claims when considered with the accompanying drawing.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a cross-sectional view of a known heat exchanger tube;

Fig. 2A shows a cross-sectional view of a first embodiment of a heat exchanger according to the present invention;

Fig. 2B shows an enlarged cross-sectional view of the heat exchanger tube of Fig. 2A;

Fig. 3 shows a cross-sectional view of a second embodiment of the heat exchanger tube;

Fig. 4 shows a cross-sectional view of a third embodiment of a heat exchanger tube according to the present invention;

Fig. 5 shows an alternate configuration of the heat exchanger tube of Fig. 4, according to the present invention;

Fig. 6 shows front view of an embodiment a heat exchanger that includes one of the heat exchanger tubes of Figs. 2-5 according to the present invention;

Fig. 7A shows an embodiment of an automobile with a heat exchanger having one of the heat exchanger tubes of Figs. 2-5 according to the present invention; and

Fig. 7B shows a residential home with an air conditioner having one of the heat exchanger tubes of Figs. 2-5 according to the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

Fig. 6 shows a heat exchanger of a so-called multi-flow type that includes a plurality of multi-bored flat tubes 1 each having a certain length, fins 2 interposed between the tubes 1, and a pair of hollow headers 3 to which the ends of the tubes 1 are connected. Each header 3 is divided by a partition 4. In operation, medium flows into the right hand header 3 through an inlet 5 connected to the upper portion of the header, passes through the left hand header 3 through an outlet 6 connected to the lower portion of the header 3.

Fig. 2A shows an embodiment of a heat exchanger tube 20 of used in a vehicle. The heat exchanger tube 20 is an aluminum extruded article. As shown in Figs. 2A and 2B the heat exchanger tube 20 extends in an axial direction and has nose ends 21. The typical length L of the heat exchanger

tube 20 is designed to be in the range of 10.0 mm to 25.0 mm. A peripheral wall 22 is formed to have an elongated circular cross-sectional shape. A plurality of divisional walls 23 are provided in the heat exchanger tube 20 to form a plurality of compartments 24, 24a arranged in the axial direction of the heat exchanger tube 20. The divisional walls 23 connect flat wall portions 25 of the peripheral walls 22 with each other at a certain distance. The thickness  $t_1$  of divisional walls 23 can be designed to be in the range of 0.15 mm to 0.45 mm while the thickness  $t_2$  of the flat wall portions 25 is designed to be in the range of 0.27 mm to 0.60 mm.

The inner surface of each of the outermost compartments 24a is formed to be a circumferentially smooth curved shape in cross-section. In this embodiment, each compartment 24a is formed to have a rounded, or semicircular, inner surface at the outermost compartment side and a rectangle at the other side. The width  $cw$  of compartment 24a is typically from 0.30 mm to 3.0 mm. The height  $ch$  of compartment 24a is typically from 0.6 mm to 3.5 mm. However, the compartment 24a may be formed to be an elongated circular cross-sectional shape, an elliptical shape or a perfect circular shape.

The plurality of inner compartments 24 are typically formed to be rectangular in shape in cross-section. The width  $w$  of an inner compartment 24 is typically designed to be 1.4 mm. However, the inner compartments 24 are not constrained to be rectangular in shape in cross-section. The inner compartments 24 can be designed to have a triangular, a trapezoidal, circular, or a star shape. A particular advantage of the present invention, in any embodiment, is that design of a major portion of the heat exchanger tube 20 is irrelevant as described below.

Attached to each of the nose ends 21 are appendages 26a, 26b. Each of the appendages 26a, 26b are spaced from one another such that appendage 26a and appendage 26b do not form an enclosed space with one another. In this embodiment, each of the appendages 26a, 26b are substantially straight and are integrally formed from the flat wall portions 25. The appendages 26a, 26b are also substantially parallel to each other. The

thickness  $t_3$  of each of the appendages 26a, 26b is designed to be from 0.2 mm to 0.5 mm. While the thickness  $t_4$  of each of the nose ends 21 is typically in the range of 0.30 mm to 0.65 mm. Each of the appendages 26a, 26b extends 0.5 mm from nose ends 21. The height  $h$ , as measured from the top of appendage 26a to the bottom of appendage 26b is designed to be  $2.01 \pm 0.04$  mm.

When the above-mentioned heat exchanger tube 20 is used in a condenser for an automobile air conditioner, the heat exchanger tube 20 may be hit by an object, such as a stone, that is passed through a radiator grill of the automobile. In this case, however, the appendages 26a 26b prevent the nose ends 21 from being damaged because typically the appendages 26a, 26b on the windward side of the heat exchanger would be hit first and collapse, absorbing the energy of the incoming stone, therefore, protecting heat exchanger tube 20.

Fig. 3 shows another embodiment of heat exchanger tube 20. In this embodiment, the straight appendages 26a, 26b of Fig. 2A have been replaced by appendages 31.

Appendages 31 are attached to the center of nose ends 21. In this embodiment, appendages 31 are substantially straight and are integrally formed from the nose ends 21. Appendages 31 extend 0.5 mm from the tip of nose ends 21 and typically have a thickness  $t_5$  of 0.44 mm.

When the above-mentioned heat exchanger tube 20 is used in a condenser for an automobile air conditioner, the heat exchanger tube 20 may be hit by an object, such as a stone, that is passed through a radiator grill of the automobile. In this case, however, the appendages 31 prevent the nose ends 21 from being damaged because typically the appendage 31 on the windward side of the heat exchanger would be hit first and collapse, absorbing the energy of the incoming object, therefore, protecting heat exchanger tube 20.

Fig. 4 shows another embodiment of heat exchanger tube 20, according to the present invention. In this embodiment, the straight

appendages 26a, 26b of Fig. 2A have been replaced by appendages 41a, 41b, respectively.

Appendages 41a, 41b are attached to nose ends 21. Each of the appendages 41a, 41b are spaced from one another such that appendage 41a and appendage 41b do not form an enclosed space with one another. In this embodiment, each of the appendages 41a, 41b are curved with a radius of curvature of typically between 0.6 and 1.5 and are integrally formed from the flat wall portions 25. The appendages 41a, 41b also face each other and end in a point. Each of the appendages 41a, 41b extend 0.5 mm from nose ends 21. The space S between each appendage 41a, 41b is preferably 1.0 mm.

When the above-mentioned heat exchanger tube 20 is used in a condenser for an automobile air conditioner, the heat exchanger tube 20 may be hit by an object, such as a stone, that is passed through a radiator grill of the automobile. In this case, however, the appendages 41a, 41b prevent the nose ends 21 from being damaged because typically the appendages 41a, 41b on the windward side of the heat exchanger would be hit first and collapse, absorbing the energy of the incoming object, therefore, protecting heat exchanger tube 20. This embodiment of the present invention provides the superior protection for heat exchanger tube 20 because of the size of space S, stones greater than or equal to 1.0 mm cannot damage the heat exchanger tube 20.

Fig. 5 shows an alternate configuration of the embodiment as shown in Fig. 4 of heat exchanger tube 20, according to the present invention. In this embodiment, the straight appendages 26a, 26b of Fig. 2A have been replaced by appendages 51a, 51b.

Appendages 51a, 51b are attached to nose ends 21. Each of the appendages 51a, 51b are spaced from one another such that appendage 51a and appendage 51b do not form an enclosed space with one another. In this embodiment, each of the appendages 51a, 51b are curved with a radius of curvature of typically between 0.6 and 1.5 and are integrally formed from the flat wall portions 25. The appendages 51a, 51b also face each other and end in a flat part 52. Each of the appendages 51a, 51b extend 0.5 mm from

nose ends 21. The space S between each appendage 51a, 51b is preferably 0.79 mm.

When the above-mentioned heat exchanger tube 20 is used in a condenser for an automobile air conditioner, the heat exchanger tube 20 may be hit by an object, such as a stone, that is passed through a radiator grill of the automobile. In this case, however, the appendages 41a, 41b prevent the nose ends 21 from being damaged because typically the appendages 41a, 41b on the windward side of the heat exchanger would be hit first and collapse, absorbing the energy of the incoming object, therefore, protecting heat exchanger tube 20. This embodiment of the present invention provides the maximum protection for heat exchanger tube 20 because of the size of space S, stones greater than or equal to 0.79 mm cannot damage the heat exchanger tube 20.

As schematically shown in Fig. 7A, the heat exchanger tubes of Figs. 2-5 and the heat exchanger 7 of Fig. 6 can be installed in an automobile 70, where the heat exchanger 7 is part of the cooling system and/or air conditioning system of the automobile. In addition, the heat exchanger tubes of Figs. 2-5 and heat exchanger 7 of Fig. 6 can be installed in an air conditioning unit positioned within a residence 71 of Fig. 7B.

The foregoing detailed description is merely illustrative of several physical embodiments of the invention. Physical variations of the invention, not fully described in the specification, may be encompassed within the purview of the claims. Accordingly, any narrower description of the elements in the specification should be used for general guidance, rather than to unduly restrict any broader descriptions of the elements in the following claims.